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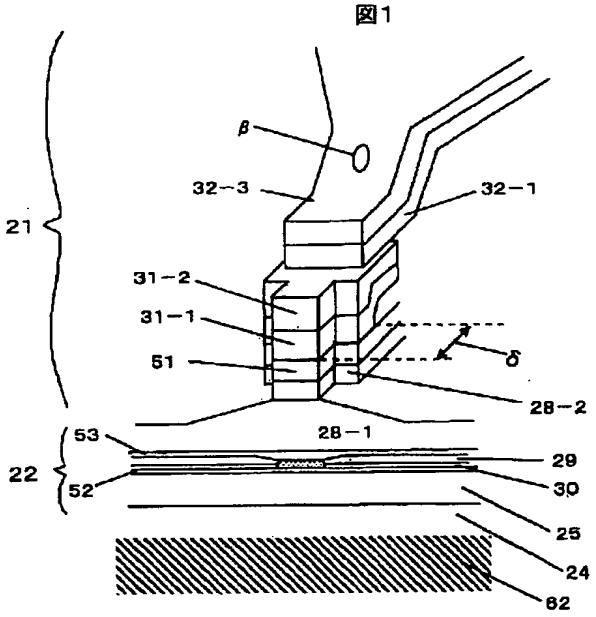
最終頁に続く

(54)【発明の名称】薄膜磁気ヘッド

(57)【要約】
【課題】磁極を繋ぐ狭トラック対応型の磁気ヘッド構造において３００ＭＨｚ以上の高周波記録動作を可能とする新規薄膜磁気ヘッドを提供することにある。
【解決手段】記録媒体と対向する第一の磁性部材と、同じく記録媒体と対向し、記録トラックの幅を規定する幾何学的な寸法幅を有する第二の磁性部材と、さらに、第二の磁性部材と第一の磁性部材を磁気的に結合する第三の磁性部材から磁気回路を構成し、かつ、これら磁性部材の各々を複数の磁性薄膜を積層して構成する共に、第一及び第二の磁性部材を構成する磁性薄膜の内、記録ギャップ層にに近い積層膜をその外側の磁性膜に比べ飽和磁束密度を高くすると共に第３の磁極部材を構成する外側磁性薄膜に高透磁率μ材、内側磁性薄膜に高比抵抗ρ材を配置した薄膜磁気ヘッドにより、高磁界発生、渦電流抑止による高周波磁束発生を可能とし、３００ＭＨｚを越える高周波記録を実現した。

図1



1

【特許請求の範囲】

【請求項１】記録媒体に近接する領域において、記録媒体と対向する複数の磁性薄膜から積層された第一の磁性部材と、記録媒体と対向する記録ギャップ層と、記録媒体と対向する複数の磁性薄膜から積層された第二の磁性部材と、複数の磁性薄膜から積層された第三の磁性部材とを順次積層させ、かつ、前記第一の磁性部材と前記第二の磁性部材の端面でエアベアリング面を構成し、第二の磁性部材は、このエアベアリング面に近接した領域では前記記録ギャップ層上に積層され、後退した領域では記録ギャップ層上の絶縁層を介して積層され、第三の磁性部材はこのエアベアリング面に近い領域では前記第二の磁性部材上に積層され、後退した領域では前記記録ギャップ層上の絶縁層及び絶縁層により包みこまれた薄膜コイルの上に積層され、さらに、このエアベアリング面から記録媒体側とは反対の後方位置で前記第一の磁性部材と前記第三の磁性部材が連結され、第一と第三の磁性部材は前記記録ギャップ層からみて外側の磁性薄膜が内側の磁性膜と同等かあるいはより高い透磁率を有し、かつ、前記記録ギャップ層と接する前記第一及び第二の磁性部材の内側磁性薄膜はそれぞれ第一及び第二の磁性部材を構成する他の磁性薄膜に比し同等かあるいはより高い飽和磁束密度を持ち、さらに、前記第一の磁性部材、前記記録ギャップ層、前記第二の磁性部材、前記第三の磁性部材、及び前記薄膜コイルを支持する基板を有する薄膜磁気ヘッド。

【請求項２】記録媒体に近接する位置において、記録媒体と対向する複数の磁性薄膜から積層された第一の磁性部材と、記録媒体と対向する記録ギャップ層と、記録媒体と対向する複数の磁性薄膜から積層された第二の磁性部材と、複数の磁性薄膜から積層された第三の磁性部材とを順次積層させ、かつ、前記第一の磁性部材と前記第二の磁性部材の端面でエアベアリング面を構成し、第二の磁性部材は、このエアベアリング面に近接した領域では前記記録ギャップ層上に積層され、後退した領域では記録ギャップ層上の絶縁層を介して積層され、第三の磁性部材はこのエアベアリング面に近い領域では前記第二の磁性部材上に積層され、後退した領域では前記記録ギャップ層上の絶縁層及び絶縁層により包みこまれた薄膜コイルの上に積層され、さらに、複数の磁性薄膜から積層された第四の磁性部材をこのエアベアリング面から遠い後方位置で前記第一の磁性部材と連結して形成し、さらにその第四の磁性部材と前記第三の磁性部材が連結され、かつ、第一と第三の磁性部材は前記記録ギャップ層からみて外側の磁性薄膜が内側の磁性膜と同等かあるいはより高い透磁率を有し、かつ、前記記録ギャップ層と接する前記第一及び第二の磁性部材の内側磁性薄膜はそれぞれ第一及び第二の磁性部材を構成する他の磁性薄膜に比し同等かあるいはより高い飽和磁束密度を持ち、さらに、前記第一磁性部材、前記記録ギャップ層、前記第二磁性部材、前記第三磁性部材、前記第四磁性部材及び前記薄膜コイルを支持する基板を有する薄膜磁気ヘッド。

2

【請求項３】第三の磁性部材を構成する磁性薄膜の記録ギャップ層から見て内側の磁性薄膜として比抵抗４０μΩ—ｃｍ以上の磁性薄膜が適用されていることを特徴とする請求項１及び２のいずれかに記載の薄膜磁気ヘッド。

【請求項４】第三の磁性部材と他の磁性部材が後方位置で連結するバックコンタクト部から、第三の磁性部材を構成する磁性薄膜に沿ってエアベアリング面に近接する際、該磁性薄膜の断面積を次第に縮小させて絞り部を形成させた後に第二の磁性部材と連結することを特徴とする請求項１乃至３のいずれかに記載の薄膜磁気ヘッド。

【請求項５】第三の磁性部材の絞り部と第二の磁性部材のエアーベアリング面からみた後端との間に０．５μｍ以上の距離を設けたことを特徴とする請求項１乃至４のいずれかに記載の薄膜磁気ヘッド。

【請求項６】前記第一の磁性部材と基板との間にシールド層及び下地膜、磁性膜、電極と共に磁気抵抗効果素子を埋設し、記録再生複合型とした請求項１乃至５のいずれかに記載の薄膜磁気ヘッド

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、電子計算機及び情報処理装置等に用いられる磁気ディスク装置用の磁気ヘッドに係り、特に３００ＭＨｚ以上の高周波記録を実現するに好適な薄膜磁気ヘッドの構成に関する。

【０００２】

【従来の技術】情報機器の記憶（記録）装置には、主に半導体メモリと磁性体メモリが用いられる。高速アクセスが必要な内部記憶装置には半導体メモリが用いられ、大容量かつ不揮発性が要求される外部記録装置には磁性体メモリが用いられる。

【０００３】今日、磁性体メモリ利用の主流は、磁気ディスク装置および磁気テープ装置である。これらに用いられる記録媒体には、Ａｌ基板ないしは樹脂のテープ上に磁性薄膜が成膜してある。これらの記録媒体に磁気情報を書き込むため、電磁変換作用を有する機能部（磁気ヘッド記録部）を有する磁気ヘッドが用いられる。また、磁気情報を再生するため、磁気抵抗現象ないしは、巨大磁気抵抗現象あるいは電磁誘導現象を利用した機能部（磁気ヘッド再生部）を有する磁気ヘッドが用いられる。

【０００４】図３に、本発明の薄膜磁気ヘッドが適用される磁気ディスク装置の基本構成の一例を示す。同図（ａ）は、装置の平面図、（ｂ）は断面図である。記録媒体１１（この例では複数の媒体１１－１～１１－４で構成）は、モータ１０に直結されており、情報の入出力時に回転する機能を有する。磁気ヘッドは、アーム１０

１を介してロータリアクチュエータ１３に支持される。サスペンション１０３は、磁気ヘッド１２を記録媒体１１に所定の荷重で押しつける機能を有する。再生信号の処理及び情報の入出力には、所定の電気回路が必要であり、ケース１０２に主に取り付けられている。

【０００５】磁気ヘッド１２は、ロータリアクチュエータ１３の回転と共に記録媒体１１面上を移動し、任意の場所に位置決めした後、磁気情報の記録（書き込み）、ないしは再生（読み出し）機能を実現する。これを制御する回路も上記信号処理回路と合わせて電気回路１４を構成している。

【０００６】磁気ヘッド１２に搭載される情報の記録（書き込み）及び再生機能部は、例えば図２に示す構造から構成される。記録（書き込み）部２１は、渦巻き型コイル２６とこれを上下に包む磁性部材（磁極）２７と磁性部材（磁極）２８から構成される。両者は磁気的に結合され、共に磁性膜パターンから構成される。

【０００７】再生部２２は、磁気抵抗効果素子２３と同素子に定電流を流し、かつ抵抗変化を検出するための電極２９から構成される。磁性部材（磁極）２８は、これら記録（書き込み）部と再生（読み出し）部の間に存在し、再生時に磁性部材（膜）２５と共にシールドとしても機能する。これらの機能部は、基板６２上に下地層２４を介して形成されている。

【０００８】上記渦巻き型コイル２６及び磁気抵抗効果素子２３は図３に示すように記録再生を実行するＲｅａｄ／ＷｒｉｔｅＩＣ（図示せず）と電気的に連結している。

【０００９】従来の磁気記録装置では、記録および再生時の周波数は１００ＭＨｚを超えることはなかった。しかしながら、将来の高密度磁気記録装置では、大量のデータを短時間に入出力させる必要性から、データ転送性能を７５ＭＢ／ｓ以上に高めなければならならず、一秒あたり７５ＭＢを一周期８ビットで２データの情報を記録するとすると（７５×８／２）ＭＨｚ以上、すなわち、３００ＭＨｚ以上の周波数で機能する記録ヘッドが必要となっている。

【００１０】磁気ディスク装置の性能向上において、上記に述べた高周波化と共に記録密度の向上も非常に重要であることは言うまでもない。両者の向上が相俟って今後の高性能化への要求を満たすことができ、その意味で両者の関連は深い。

【００１１】記録密度の向上に関しては、例えば特開平１１－１６７７０５号、特開平１１－３１２３０３号、特開平１１－３１２３０４号等の公報で新たな磁極構成が提案されている。開示された磁極構成を図４に示す。これらの例の共通点は、記録トラック幅を決める磁極３１とコイルを包む磁極３２とを異なる工程で作製し、その後の工程で連結している点にある。

【００１２】記録トラックの密度を高めるためには、幾

何学的に狭い幅（具体的には、０．５μｍ以下）の磁極３１の形成が必要となる。しかしながら、磁極３１のパターニングを従来ヘッドのようにコイル形成後にコイルを包む磁極３２と同時におこなうと、パターン形成用ホトレジストの膜厚に数μｍ以上の段差（磁極３１対応部分が厚くなる）を生じ、磁極３１に対して狭い幅のパタン形成が困難となる。

【００１３】この困難を解決するために磁極３１と磁極３２の形成を分離し、まず高精度な狭い幅のパターニングが必要な磁極３１を形成した後、精度的に裕度のあるコイルを包む磁極３２を後工程で形成することで狭トラック化を可能にするものである。このように磁極を別々に形成し、繋ぐ構成にすると、コイル形成後に生じる高い段差の影響を受けずに狭トラックの磁極を形成できる長所がある。この方法により１μｍ以下の幾何学寸法を有するトラック幅を形成できることが確認されている。なお、図の例ではシールド２８上に凸状のパターンγが形成されている。これは、磁極３１をマスクにシールド２８の表面をイオンミリング法でエッチングして形成したものであり、この形状には記録にじみを少なくする効果があることが開示されている。

【００１４】上述の開示例による磁気ヘッドにおける、狭トラック幅の実現は、高記録密度化において、有効な基礎技術となり得るものである。しかしながら、今後の磁気記録技術におけるもう一つの技術課題である高周波数化の実現へと発展させ、３００ＭＨｚの高周波記録を実現する技術に関する内容は、開示された公知例には、含まれていない。わずかに特開平１１－１６７７０５号において、図４に示す磁性膜２８及び３２の少なくとも一方をパーマロイとの比較において高抵抗材料で構成することもでき、その場合、パーマロイを用いた場合に比し、高周波化された場合の渦電流損失を低減できることを述べているのみである。この開示内容で３００ＭＨｚの高周波記録を実現することはできない。

【００１５】

【発明が解決しようとする課題】記憶装置の性能は、記憶容量と記録、読み出し時の動作スピードによって評価される、製品競争力を高めるためには、大容量化とアクセス時間の短縮化が必須であることは言うまでもない。しかし、これまでに開示された技術は、狭トラック化を実現するための技術に限られており、もう一つの目標である高周波記録、なかんずく、今後の重要技術課題である３００ＭＨｚの高周波記録を達成する構成に関する開示はない。

【００１６】本発明の目的は、磁極を繋ぐ狭トラック対応型の磁気ヘッド構造において３００ＭＨｚ以上の高周波記録動作を可能とする新規磁極構成、なかんずく、新規薄膜磁気ヘッドを開示することにある。

【００１７】さらに、かかる薄膜磁気ヘッドの製造において、そのプロセスを簡素化できる構造をも合わせて開

示する。

【００１８】

【課題を解決するための手段】上記目的を実現するため、本発明では下記の手段を用いた。まず、薄膜磁気ヘッドの記録機能部を構成する各磁性部材を複数の磁性薄膜により形成し、従来の単層膜の組み合わせでは実現できなかった磁気特性を実現し、媒体対向面に形成された対となる磁性部材から強磁界発生可能な磁気回路を形成させると共に渦電流発生による高周波特性の劣化を防止する構造とし、これらの手段により、薄膜磁気ヘッドの高周波特性の向上を実現した。

【００１９】また、かかる複数磁性膜の組み合わせによる磁気回路構成により基本的特性の向上を図ると共に、寸法をふくむ幾何学的構造に依存する磁界分布、磁界強度の改良向上も合わせて、薄膜磁気ヘッドの高周波特性の更なる向上を実現した。

【００２０】薄膜磁気ヘッドの構成として、まず、記録媒体と対向する第一の磁性部材と、同じく記録媒体と対向し、記録トラックの幅を規定する幾何学的な寸法幅を有する第二の磁性部材さらに、第二の磁性部材と第一の磁性部材を磁気的に結合する第三の磁性部材から磁気回路を構成し、かつ、これら磁性部材の各々を複数の磁性薄膜を積層して構成する共に、第一の磁性部材及び第二の磁性部材を各々構成する磁性薄膜において、記録ギャップ層に近い積層膜をギャップから離れた位置の磁性膜に比べ飽和磁束密度を高くした。

【００２１】また、上記第一及び第三の磁性部材において記録ギャップ層に対して遠ざかる層に透磁率の高い性質を有する磁性膜を配置した。

【００２２】また、エアギャップ面から遠い後方位置での第一と第三の磁性部材の連結において、第四の磁性部材を介在させることにより、本発明の薄膜磁気ヘッドの製造において、そのプロセスの簡素化を図った。

【００２３】また、第３の磁極部材を構成する積層膜の一部に比抵抗４０μΩ—ｃｍ以上の薄膜を適用した。

【００２４】また、第三の磁性部材と他の磁性部材が後方位置で連結するバックコンタクト部から、第三の磁性部材を構成する磁性薄膜に沿ってエアベアリング面に近接する際、該磁性薄膜の断面積を次第に縮小させて絞り部を形成させた後に第二の磁性部材と連結する構成にした。

【００２５】また、第３の磁極部材の前記絞り部と第２の磁極部材のエアーベアリング面からみた後端との間に0.5μm以上の距離を設けた。

【００２６】

【発明の実施の形態】本発明の実施の形態を実施例にもとづき図面を参照して説明する。図１は本発明の第一の実施例である薄膜磁気ヘッドの記録再生素子の主要部を示す斜視概略図である。この薄膜磁気ヘッドは、再生部２２と記録部２１からなるが、本発明の基本概念は、この記録部２１の構成にある。まず、この記録部の第一の磁性部材２８は、再生部２２のシールド層と記録部の下部磁極の機能を兼用する。この上に、アルミナから構成される記録ギャップ層５１を配置し、さらに第二の磁性部材３１を配置する。第二の磁性部材３１は従来の磁気ヘッドと同様、記録トラックの幅を規定する。さらに第二の磁性部材３１と第一の磁極部材を磁気的に結合する第三の磁極部材３２を後端位置に配置し磁気回路を構成する。

【００２７】本発明では、記録部を構成する磁性部材の各々を複数の磁性薄膜を積層して構成し、各磁性薄膜の電磁気特性の相互関係を制御することにより媒体対向面に形成された対となる磁性部材から強磁界発生可能な磁気回路を形成させると共に渦電流発生による高周波特性の劣化を防止する構造を実現する点にポイントがある。かかる複数の磁性薄膜の積層において、まず、記録ギャップ層５１と接する磁性部材において、これを構成する積層磁性薄膜の内、記録ギャップ層５１と接する磁性薄膜の飽和磁束密度を、同磁性部材を構成する他の積層磁性薄膜磁性膜の飽和磁束密度より高くした。さらに、第一と第三の磁性部材は記録ギャップ層からみて外側の磁性薄膜が内側の磁性膜より高い透磁率を有する配置とした。本発明において、飽和磁束密度および透磁率の両者が上述の関係にあることが望ましい。ただし、前者の飽和磁束密度が同等の場合は、後者の透磁率が上述の関係にあれば、その分の効果は実現する。また、後者の透磁率が同等の場合は、飽和磁束密度が上述の関係にあれば、その分の効果は実現する。

【００２８】本実施例において具体的には、磁性薄膜２８－１と磁性薄膜２８－２の積層膜からなる第一の磁性部材２８において、記録ギャップ層５１と接する磁性薄膜２８－２はＣｏ、Ｎｉ、Ｆｅの少なくとも三元素を含む合金からなり、Ｂｓ（飽和磁束密度）は２．０テスラ（Ｔ）、膜厚は０．５μｍである。記録ギャップ膜８１と接していない磁性薄膜２８－１は８０Ｎｉ－Ｆｅ（組成比Ｎｉが８０ａｔ％；以下同様表示）からなり、Ｂｓが１．０Ｔ、膜厚は２．０μｍである。したがって、記録ギャップ層５１と接する磁性薄膜２８－２が記録ギャップ膜８１と接していない磁性薄膜２８－１よりも飽和磁束密度の高い磁性薄膜となっている。

【００２９】また、磁性薄膜３１－１と磁性薄膜３１－２の積層膜からなる第二の磁性部材３１については、記録ギャップ層８１と接する磁性薄膜３１－１がＣｏ、Ｎｉ、Ｆｅの少なくとも三元素からなる合金からなり、Ｂｓは２．０Ｔ、膜厚が０．５μｍである。記録ギャップ膜５１と接していない磁性薄膜３１－２は４６Ｎｉ－Ｆｅからなり、Ｂｓが１．６Ｔ，膜厚が２．０μｍである。したがって、記録ギャップ層８１と接する磁性薄膜３１－１が記録ギャップ膜５１と接していない磁性薄膜３１－２よりも飽和磁束密度の高い磁性薄膜となってい

る。また、この第二の磁性部材は、エアベアリング面の近接領域では記録ギャップ層５１上に積層され、後退した領域では記録ギャップ層上の絶縁層（図５の５４）を介して積層されている。図５については、第四の磁性部材を加えた第二の実施例として後述するが、これを除いた部分の構成は基本的に第一の実施例と同様である。

【００３０】また、第一及び第三の磁性部材において、記録ギャップ層５１からみて外側に透磁率の高い性質を有する磁性膜を配置するという点では、前述の第一の磁性部材では外側の磁性薄膜２８－１が内側の磁性薄膜２８－２より高い透磁率を有しており、そのような配置となっている。同様の目的で第三の磁性部材の外側に高８０Ｎｉ－Ｆｅ薄膜３２－３を配置し、この第三の磁性部材の内側には、飽和磁束密度は高いが、上記外側の磁性薄膜より透磁率の低い４６Ｎｉ－Ｆｅの薄膜３２－１を配置した。膜厚は、８０Ｎｉ－Ｆｅが２．０μｍ、４６Ｎｉ－Ｆｅが１．０μｍである。この第三の磁性部材はエアベアリング面に近い領域では第二の磁性部材上に積層され、後退した領域では記録ギャップ層上の絶縁層（図５の５４）および薄膜コイルを包む絶縁層上（図５の５５）に積層され、さらに、このエアベアリング面から記録媒体側とは反対の後方位置で、第一の磁性部材と連結している。

【００３１】ここで第三の磁極部材の内側磁性薄膜に適用した４６Ｎｉ－Ｆｅの比抵抗は４０μΩ―ｃｍである。このような比抵抗値を有する膜を積層した理由は、渦電流の発生を防止することにある。比抵抗が高いほど渦電流の発生を低減できることは良く知られている。従って、さらに比抵抗の高い膜の適用も望ましい。但し、飽和磁束密度Ｂｓに関する条件と両立させる必要が有り、この内側磁性薄膜は外側の磁性膜に比べ同等かあるいはより高い飽和磁束密度Ｂｓを持つようにしなければならない。

【００３２】この条件が必要な理由は、第三の磁性部材からの第二の磁性部材に磁束が流れる際に内側の膜のＢｓが低いと飽和現象が生じ効率が低下し、強磁界発生の障害となるためである。

【００３３】第三の磁性部材３２を形成するに際しては、図１に示したように、その先端部がエアベアリング面からスロートハイトδと略等しい距離だけ後方に位置するようにパターンを設ける。この理由は、第三の磁性部材からの磁界で隣接するトラック情報を消去するケースが生じるのを防ぐためである。具体的には、第三の磁性部材の先端部をエアベアリング面から約1μｍ後退させて設けておけば、このような不具合が生じるおそれはない。

【００３４】上記の記録部２１と組み合わされる図１の再生部２２は、基板６２の上に下地層２４を介して、磁性部材２５、電極２９、磁気抵抗効果素子２３等から形成される。第一の磁性部材２８－１は再生時には磁性部材２５と共にシールドとして機能する。

【００３５】また、上記の構成において再生部２２のシールド層と記録部の下部磁極をＡｌ２Ｏ３，ＳｉＯ２，Ｔａ等の間に非磁性膜を積層し磁気的に分離した構成としてもよい。この構成においては、第１の磁性部材が記録部の下部磁極としての役割を果たすことになる。この例においても、記録ギャップから遠いシールド層の透磁率を高く、記録ギャップに近い下部磁極の飽和磁束密度を高くする必要が有ることは言うまでもない。さらに、再生部を基板で置きかえれば、記録部のみを持つ本発明の薄膜磁気ヘッドとなる。

【００３６】上記に述べた記録機能部の構造は、第二の磁性部材と第一の磁性部材をエアベアリング面から遠い位置では、第三の磁性部材を介して磁気的に結合する構造となっている。これに対し、後方位置では、第一の磁性部材と第三の磁性部材が第四の磁性部材を介して連結する構造（図５に示す）とすれば、後述するように、本発明の薄膜磁気ヘッドの素子製造工程の短縮化に有利な構造とすることができる。

【００３７】すなわち、図５に示す第二の実施例では記録媒体と対向する第一の磁性部材２８と、同じく記録媒体と対向し、記録トラックの幅を規定する幾何学的な寸法幅を有する第二の磁性部材３１、第二の磁性部材と同じ積層構造から形成された第四の磁性部材３４がエアベアリング面から遠い後方位置で前記第一の磁性部材２８と連結し、さらに、第二の磁性部材３１と第四の磁性部材３４を磁気的に結合する第三の磁極部材３２から磁気回路を構成するものである。なお、図５には、すでに触れたように記録ギャップ層上の絶縁層５４、薄膜コイルを包みこむ絶縁層５５も合わせて示した。これらの絶縁層の配置は第一の実施例においても同様である。

【００３８】この構造は、第二の磁性部材と第四の磁性部材を同一工程で形成することが可能となるという特徴がある。これにより、第二の磁性部材形成後に実施するＣＭＰ（化学機械研磨）工程で第二の磁性部材と第四の磁性部材の表面が同時に露出するため、後方位置における磁性部材間の連結工程が容易となり、この工程を短縮することができる。この工程の短縮により安価な磁気ヘッド製造が可能となる。

【００３９】第四の磁性部材を加えた上記構造においても、磁極部材の各々を複数の磁性薄膜を積層して構成すると共に、各磁性部材及び各磁性部材を構成する各多層磁性薄膜の特性の相互関係を第一の実施例と同様な関係とすることにより上記第１の実施例と同様の高周波特性向上効果を得ることが出来る。

【００４０】なお、本発明では、図１に示すように第三の磁性部材３２と他の磁性部材が後方位置で連結するバックコンタクト部から、第三の磁性部材３２を構成する磁性薄膜に沿ってエアベアリング面に近接する際、該磁性薄膜の断面積を次第に縮小させて絞り部βを形成させ

た後に第二の磁性部材３１と連結する形状としている。かかる形状とする理由は、トラック幅を規定する第二の磁性部材に高飽和磁束密度Ｂｓの膜を配置したことによる磁束の飽和を避ける点にある。すなわち、磁路断面積が狭く、かつ、この部分のＢｓが高い条件下では、磁極エッジαが飽和しやすくなる。磁極エッジが飽和すると磁化遷移を曲げる結果となり、記録分解能を低下させ高密度記録が出来なくなる。この問題を避けるため、第三の磁性部材の断面積を部位βで絞った後に，その絞り幅をしかるべき長さ（範囲）で保った後に第二の磁性部材と連結し、絞り量を磁極先端エッジが飽和しない範囲に押さえるよう調整した。この調整は、マスクパターンの幾何学的な寸法で可能であり、素子形成の段階では膜厚で調整することが出来る。

【００４１】第三の磁性部材の絞り部にて上記に述べたような磁界の調整を行うために、第二の磁性部材後端と絞り位置の関係を検討した。両者が極端に接近した場合、第二の磁性部材と絞り位置が接近し、磁気的な絞り効果が薄れてしまう。また、逆に離れすぎた場合、絞った磁界がさらに減衰し所望の磁界が得られなくなる。両者を勘案すると上記距離として０．５μｍから１．５μｍの範囲が適値であった。

【００４２】また、再生部のシールド層と下部磁極を分離した構成においては、第一の磁性部材が下部磁極の役割を果たすことになる。この場合、記録ギャップ側に高Ｂｓ膜、記録ギャップに対し離れた膜（高Ｂｓ膜の下層膜）に４６ＮｉＦｅ膜（高Ｂｓ膜に比べ比抵抗ρが高く、同高Ｂｓ膜に対して透磁率μが高い）を配置した。この構成も本発明の請求項に記載される基本構成に準ずる構成であり、本発明の基本概念の範疇に入るものである。なお、この構成においては、シールド層と下部磁極が磁気的に遮断される傾向となるため、再生部が受ける記録磁界の影響が少なくなる。この効果から、再生出力が安定する長所を有する。

【００４３】図６に本発明の薄膜磁気ヘッド及び従来薄膜磁気ヘッドの高周波記録特性を比較して示した。両ヘッドとも再生素子部には同様の磁気抵抗効果素子を用い、記録素子部に本発明の第一の実施例に示した記録素子部を用いた場合と、図４で示した従来の記録素子部を用いた場合を比較した。従来ヘッドの記録素子部の場合、磁性層２８は８０ＮｉＦｅ膜，磁性層３１は４６ＮｉＦｅ膜，磁性層３２には８０ＮｉＦｅ膜をそれぞれ用いた。横軸が記録周波数（ＭＨｚ単位）、縦軸が信号のオーバライト特性（ｄＢ単位）である。同図（ａ）が従来、（ｂ）が本発明のヘッドによる高周波特性の測定結果であり、本発明の薄膜磁気ヘッドにより、高周波特性が大幅に向上しており、従来ヘッドでは実現できなかった３００ＭＨｚを越える高周波記録において、３０ｄＢ以上の高品質な再生信号を得ることができた。

【００４４】以上の実施例で明らかなように、記録媒体に近接する領域において、記録媒体と対向する複数の磁性薄膜から積層された第一の磁性部材、記録媒体と対向する記録ギャップ層、記録媒体と対向する複数の磁性薄膜から積層された第二の磁性部材と、複数の磁性薄膜から積層された第三の磁性部材を順次積層させ、かつ、第一の磁性部材と第二の磁性部材の端面でエアベアリング面を構成し、第二の磁性部材は、このエアベアリング面の近接領域では記録ギャップ層上に積層され、後退した領域では絶縁層を介して膜厚を減じて積層され、第三の磁性部材はこのエアベアリング面に近い先端領域では第二の磁性部材上に積層され、後退した領域では記録ギャップ層上の絶縁層及び薄膜コイルを包む絶縁層上に積層され、さらに、このエアベアリング面から記録媒体側とは逆の遠い後方位置で前記第一の磁性部材と第三の磁性部材が連結され、第一と第三の磁性部材は記録ギャップ層からみて外側の磁性薄膜が内側の磁性膜より高い透磁率を有し、かつ、記録ギャップ層と接する前記第一及び第二の磁性部材の内側磁性薄膜はそれぞれ第一及び第二の磁性部材を構成する他の磁性薄膜に比し同等かより高い飽和磁束密度を持ち、さらに、前記磁性部材の間に絶縁分離された薄膜コイルと、前記第一の磁性部材、記録ギャップ層、第二の磁性部材、第三の磁性部材、及び薄膜コイルを支持する基板を有することを特徴とする薄膜磁気ヘッドによって、従来薄膜ヘッドによる場合に比し、磁気記録の高周波記録特性を大幅に向上することができた。

【００４５】さらに、第一の磁性部材と第三の磁性部材を第四の磁性部材で連結し、第四の磁性部材と第二の磁性部材を同一工程において形成する構造とすることにより、素子形成工程の短縮化を実現することができた。

【００４６】

【発明の効果】本発明によれば、複数の磁性部材を各々複数の多層磁性薄膜から構成し、それら相互の磁気特性を制御することにより、高磁界発生、かつ、渦電流を抑止した状態で高周波磁束を高効率で発生できる薄膜磁気ヘッドを実現することができた。その結果、磁気記録において、記録密度の向上と共に重要課題とされていた高周波記録特性の大幅に向上を実現することができた。

【００４７】本発明の薄膜磁気ヘッドのこの性能は、高密度記録に適した高Ｈｃ（保磁力）の媒体に高周波の記録を実現する上で好適である。

【図面の簡単な説明】

【図１】　本発明の第一の実施例の薄膜磁気ヘッド素子主要部の斜視概略図。

【図２】　従来の磁気ヘッド素子主要部の斜視概略図。

【図３】　磁気ディスク記録装置の概略図。

【図４】　磁極をつなぐ構成を有する従来の磁気ヘッド素子主要部の斜視概略図。

【図５】　本発明の第２の実施例の薄膜磁気ヘッド素子部の断面図。

11

【図６】　本発明の薄膜磁気ヘッドと従来の薄膜磁気ヘッドによる記録の周波数特性の比較。

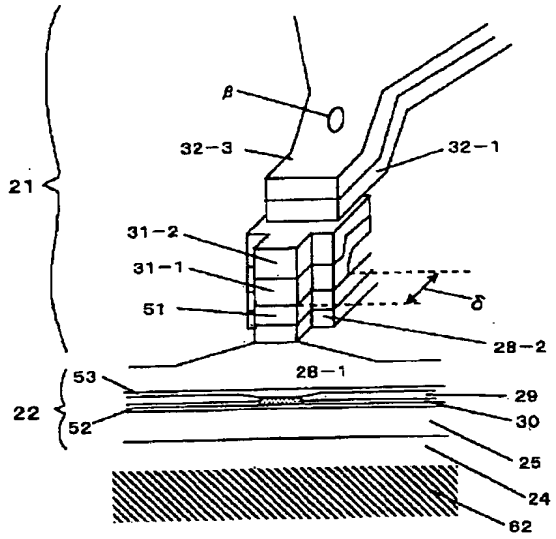
【符号の説明】

１０　モータ、１１　記録媒体、１２　磁気ヘッド、１３　ロータリアクチュエータ、１４　電気回路、１５　電気配線、２１　記録部（書き込み部）２２　再生部（読み出し部）、２３　磁気抵抗効果素子、２４　下地層、２５　下部磁極、２６　薄膜コイル、２７　上部磁極、２８第１の磁性部材（シールド層）、２９　電極、３０　磁区制御層、３１　第２の磁性部材、３２　第３の磁性部材、３４　第４の磁性部材、５１　記録ギャップ層、５２　下部絶縁層、５３　上部絶縁層、５４　記録ギャップ層上の絶縁層、　５５　薄膜コイルを包む絶縁層、６２　基板（磁気ヘッド本体）、１０１　アーム、１０２　ケース、１０３　サスペンション、２８－２，３１－１　高飽和磁束密度膜（Ｃｏ、Ｎｉ、Ｆｅの少なくとも三元素から成る合金磁性膜）、２８－１、３２－３　高透磁率膜（８０ＮｉＦｅ：パーマロイ膜）、３２－１　高比抵抗膜（４６ＮｉＦｅ：パーマロイ膜）、α　磁極エッジ、β　絞り込み部位、γ　凸状のパターン、δ　スロートハイト。

12

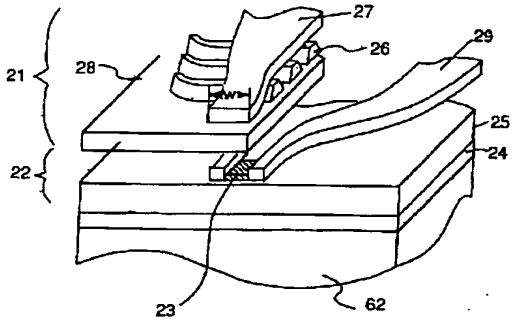
【図１】

図1



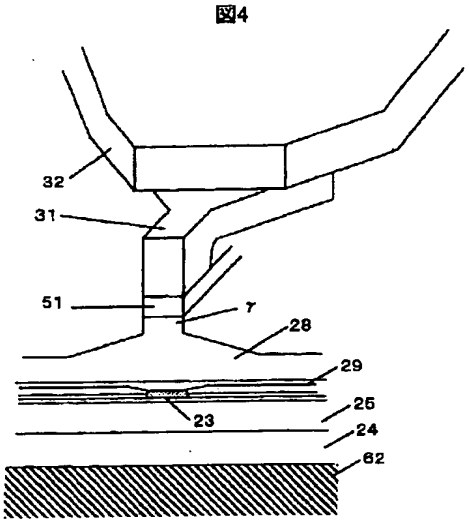
【図２】

図2



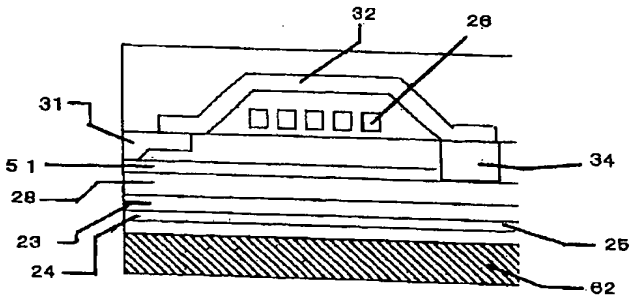
【図４】

図4



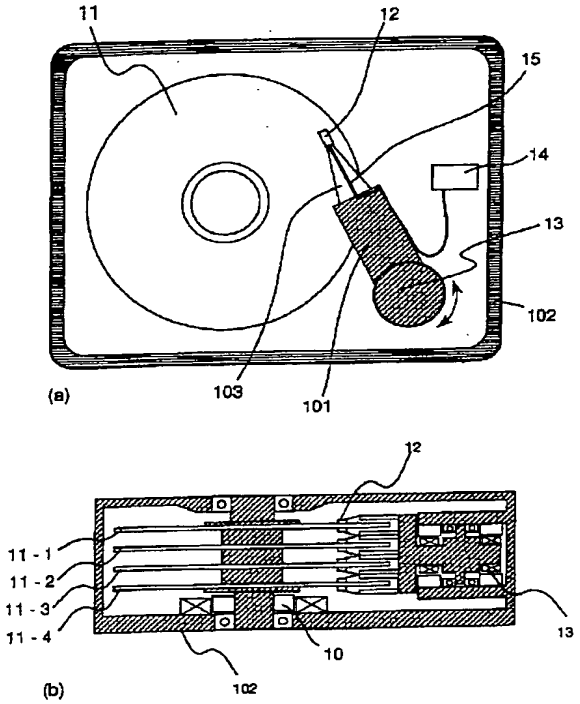
【図５】

図5



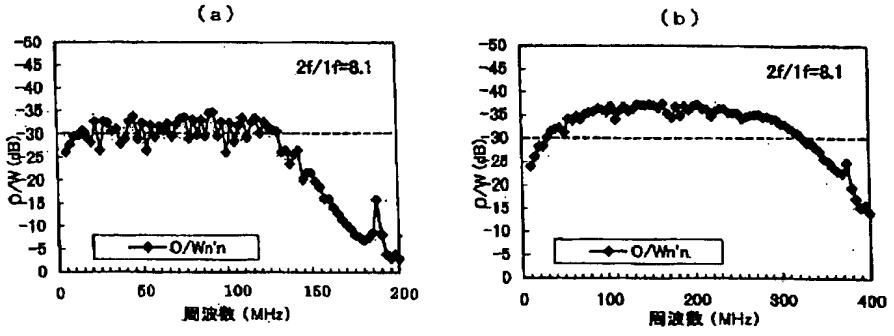
【図３】

図３



【図６】

図６



従来磁気ヘッド　　本発明の磁気ヘッド

周波数特性の比較

フロントページの続き

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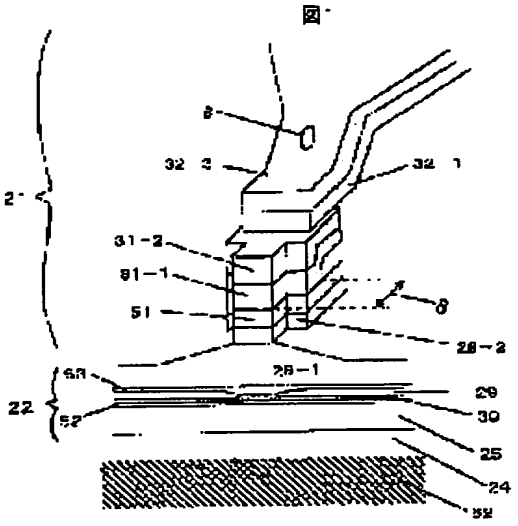
IWAKURA TADAYUKI

(54) THIN FILM MAGNETIC HEAD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a new thin film magnetic head capable of high frequency recording action of 300 MHz in a magnetic head structure dealing with narrow tracks and having magnetic poles connected.
SOLUTION: The new thin film magnetic head has a magnetic circuit constituted of a first magnetic member facing a magnetic medium, a second magnetic member facing the magnetic medium and having s geometrical dimensional width for regulating a recording track width and a third magnetic member magnetically bonding the first and the second magnetic members. These respective members are constituted of plural magnetic thin films which are laminated. And saturation magnetic flux density of a laminated film near to a recording gap layer of the magnetic thin films constituting the first and the second magnetic members is specified to be higher than that of its outside magnetic film and a high magnetic permeability μ material and a high specific resistance ρ material are disposed on the outer magnetic thin film and the inner magnetic thin film which construct the third magnetic member, respectively, to form the thin film magnetic head. Thus, generation of a high magnetic field and generation of high frequency magnetic flux by suppressing eddy current are made possible and high frequency recording over 300 MHz is realized.



LEGAL STATUS

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[Date of final disposal for application]

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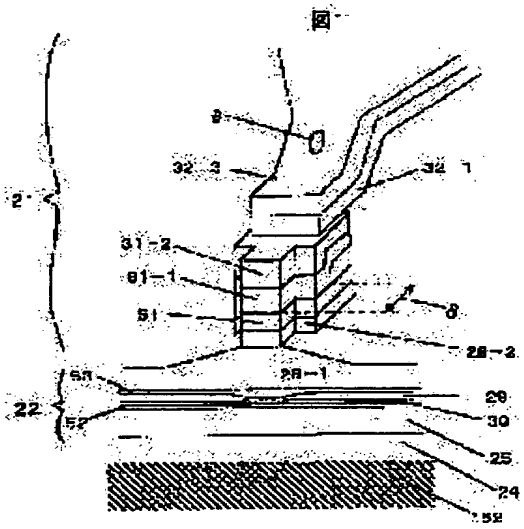

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Patent number]
Date of registration]
Number of appeal against examiner's decision of ejection]
Date of requesting appeal against examiner's decision

NOTICES *

LAIMS

Claim(s)]
Claim 1] The field close to a record medium characterized by providing the following the first magnetism by which ıe laminating was carried out to the record medium from two or more magnetic thin films which counter -- a member . record medium and the record gap layer which counters the second magnetism by which the laminating was carried ıt to the record medium from two or more magnetic thin films which counter -- a member A pneumatic bearing side constituted from an end face of a member. the laminating of the third magnetic member by which the laminating was ırried out from two or more magnetic thin films is carried out one by one -- making -- and the magnetic member of ıe above first and the second magnetism of the above -- the second magnetic member In the field close to this ıeumatic bearing side, a laminating is carried out on the aforementioned record gap layer. It turns a laminating up. in ıe field which retreated, a laminating is carried out through the insulating layer on a record gap layer -- having -- a eld with the third magnetic member near this pneumatic bearing side -- the second magnetism of the above -- a ıember -- A laminating is carried out on the thin film coil wrapped in the field which retreated by the insulating layer ıd insulating layer on the aforementioned record gap layer. Furthermore, the magnetic member of the above first and ıe magnetic member of the above third are connected from this pneumatic bearing side in a back position opposite to record-medium side. In view of the aforementioned record gap layer, the first and the third magnetic member have an utside magnetic thin film equivalent to an inside magnetic film, or have higher permeability. It has higher saturation ıagnetic flux density. and the aforementioned first which touches the aforementioned record gap layer and the second ıagnetism -- the inside magnetic thin film of a member being compared with other magnetic thin films which ɔnstitute the first and second magnetic members, respectively, and it being equivalent or Furthermore, the magnetic ıember of the above first, the aforementioned record gap layer, the magnetic member of the above second, the ıagnetic member of the above third, and the substrate that supports the aforementioned thin film coil
Claim 2] The position close to a record medium characterized by providing the following the first magnetism by ′hich the laminating was carried out to the record medium from two or more magnetic thin films which counter -- a ıember A record medium and the record gap layer which counters the second magnetism by which the laminating was arried out to the record medium from two or more magnetic thin films which counter -- a member A pneumatic earing side is constituted from an end face of a member. the laminating of the third magnetic member by which the ıminating was carried out from two or more magnetic thin films is carried out one by one -- making -- and the ıagnetic member of the above first and the second magnetism of the above -- the second magnetic member In the field lose to this pneumatic bearing side, a laminating is carried out on the aforementioned record gap layer. It turns a ıminating up. in the field which retreated, a laminating is carried out through the insulating layer on a record gap layer - having -- a field with the third magnetic member near this pneumatic bearing side -- the second magnetism of the bove -- a member -- A laminating is carried out on the thin film coil wrapped in the field which retreated by the ısulating layer and insulating layer on the aforementioned record gap layer. Furthermore, from two or more magnetic ıin films, connect with the magnetic member of the above first the fourth magnetic member by which the laminating ′as carried out, and it is formed in a back position distant from this pneumatic bearing side. Furthermore, the fourth ıagnetic member and magnetic member of the above third are connected. In view of the aforementioned record gap ıyer, the first and the third magnetic member have an outside magnetic thin film equivalent to an inside magnetic film, ır have higher permeability. It has higher saturation magnetic flux density. and the aforementioned first which touches ıe aforementioned record gap layer and the second magnetism -- the inside magnetic thin film of a member being ompared with other magnetic thin films which constitute the first and second magnetic members, respectively, and it ′eing equivalent or furthermore, the aforementioned first magnetism member, the aforementioned record gap layer, the foremention second magnetism member, the aforementioned third magnetism member, and the above -- the ubstrate which supports a member and the aforementioned thin film coil the fourth magnetism

laim 3] The thin film magnetic head given in either of the claims 1 and 2 characterized by seeing from the record ɔ layer of the magnetic thin film which constitutes the third magnetic member, and applying the magnetic thin film ɔre than 40micro ohm-cm of specific resistance as an inside magnetic thin film.
laim 4] The thin film magnetic head according to claim 1 to 3 characterized by connecting with the second magnetic ɜmber after making the cross section of this magnetic thin film reduce gradually and making a converging section m, in case the third magnetic member and other magnetic members approach a pneumatic bearing side from the ck-contact section connected in a back position along with the magnetic thin film which constitutes the third ıgnetic member.
laim 5] the third magnetism -- the converging section of a member, and the second magnetism -- the thin film ıgnetic head according to claim 1 to 4 characterized by establishing distance 0.5 micrometers or more between the ck end seen from the pneumatic bearing side of a member
laim 6] The thin film magnetic head according to claim 1 to 5 which laid the magnetoresistance-effect element derground with the shield layer and the ground film, the magnetic film, and the electrode between the magnetic ɜmber of the above first, and the substrate, and was made into the record reproduction compound die

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ranslation done.]

ETAILED DESCRIPTION

etailed Description of the Invention]
001]
he technical field to which invention belongs] this invention relates to the composition of the suitable thin film
ignetic head to start the magnetic head for magnetic disk units used for a computer, an information processor, etc.,
d realize RF record of 300MHz or more especially.
002]
escription of the Prior Art] Semiconductor memory and magnetic-substance memory are mainly used for the storage
cord) equipment of information machines and equipment. Semiconductor memory is used for the internal storage
hich needs rapid access, and magnetic-substance memory is used for the external recording device as which large
pacity and a non-volatile are required.
003] The mainstream of magnetic-substance memory use is a magnetic disk unit and a magnetic tape unit today. In
e record medium used for these, the magnetic thin film is formed on aluminum substrate or the tape of a resin. in
der to write magnetic information in these record media -- electromagnetism -- the magnetic head which has the
nction part (magnetic-head Records Department) which has a conversion operation is used Moreover, in order to
produce magnetic information, the magnetic head which has a function part (magnetic-head reproduction section)
ing the magnetic-reluctance phenomenon, the huge magnetic-reluctance phenomenon, or the electromagnetic-
duction phenomenon is used.
004] An example of the basic composition of the magnetic disk unit by which the thin film magnetic head of this
vention is applied to drawing 3 is shown. This drawing (a) is a plan of equipment and (b) is a cross section. The
cord medium 11 (two or more media 11-1 to 11-4 constitute from this example) is directly linked with the motor 10,
d has the function rotated at the time of informational I/O. The magnetic head is supported by the rotary actuator 13
rough an arm 101. A suspension 103 has the function which forces the magnetic head 12 on a record medium 11 by
e predetermined load. A predetermined electrical circuit is required for processing of a regenerative signal, and
formational I/O, and it is mainly attached in the case 102.
005] After the magnetic head's 12 moving with rotation of a rotary actuator 13 in the 11th page top of a record
edium and positioning in arbitrary places, record (writing) of magnetic information or a reproduction (read-out)
nction is realized. The circuit which controls this also constitutes the electrical circuit 14 together with the above-
entioned digital disposal circuit.
0006] The informational record (writing) and the informational regenerative function section which are carried in the
agnetic head 12 consist of structures shown in drawing 2 . The record (writing) section 21 consists of a whorl type
oil 26, a magnetic member (magnetic pole) 27 which wraps this up and down, and a magnetic member (magnetic
ole) 28. It is combined magnetically and both consist of [both] magnetic-film patterns.
0007] The reproduction section 22 consists of electrodes 29 for passing a constant current to the magnetoresistance-
ffect element 23 and an allotropy child, and detecting resistance change. The magnetic member (magnetic pole) 28
xists between these record (writing) section and the reproduction (read-out) section, and functions also as a shield
ith the magnetic member (film) 25 at the time of reproduction. These function parts are formed through the ground
ayer 24 on the substrate 62.
0008] The above-mentioned whorl type coil 26 and the magnetoresistance-effect element 23 are electrically connected
ith Read/WriteIC (not shown) which performs record reproduction as shown in drawing 3 .
0009] In the conventional magnetic recording medium, the frequency at the time of record and reproduction did not
xceed 100MHz. However, in the future high-density magnetic recording medium, if a data transfer performance is not
aised to 75 or more MB/s and it is an oak, supposing it records the information on two data by 8 bits a round term
75x8/2), more than MHz, i.e., the recording head which functions on the frequency of 300MHz or more, is needed [in

* and 75MB per second,] from the need of making a lot of data outputting and inputting for a short time.
)010] In the improvement in a performance of a magnetic disk unit, it cannot be overemphasized that improvement in :cording density is also very important with RF-izing described above. Improvement in both can fill the demand to ıture highly-efficient-izing conjointly, and both relation is deep in the meaning.
)011] About improvement in recording density, new magnetic pole composition is proposed, for example in official :ports, such as JP,11-167705,A, JP,11-312303,A, and JP,11-312304,A. The indicated magnetic pole composition is ıown in drawing 4 . The common feature of these examples is in the point which produced the magnetic pole 31 hich determines recording track width of face, and the magnetic pole 32 which wraps a coil at a different process, and ıs been connected at the subsequent process.
)012] In order to raise the density of a recording track, formation of the magnetic pole 31 of narrow width of face pecifically 0.5 micrometers or less) is geometrically needed. However, if patterning of a magnetic pole 31 is erformed simultaneously with the magnetic pole 32 which wraps a coil after coil formation like a head before, the :vel difference (magnetic pole 31 corresponding point becomes thick) of several micrometers or more will be :oduced in the thickness of the photoresist for pattern formation, and the pattern formation of narrow width of face ill become difficult to a magnetic pole 31.
)013] In order to solve this difficulty, after it separates formation of a magnetic pole 31 and a magnetic pole 32 and ıtterning of highly precise narrow width of face forms the required magnetic pole 31 first, ** truck-ization is enabled y forming the magnetic pole 32 which wraps the coil which has tolerance in precision at a back process. Thus, when a ıagnetic pole is formed separately and made the composition to connect, there is the advantage which can form the ıagnetic pole of a ** truck, without being influenced of the high level difference produced after coil formation. It is ıecked that the width of recording track which has the geometrical size of 1 micrometer or less by this method can be ırmed. In addition, in the example of drawing, the shield 28 convex-like pattern gamma is formed. This **********s ıe front face of a shield 28 by the ion milling method, and forms a magnetic pole 31 in a mask, and it is indicated that ıere is an effect which lessens record bleeding in this configuration.
)014] Realization of the ** width of recording track in the magnetic head by the above-mentioned example of an ıdication may serve as effective basic technology in a raise in recording density. however, it is made to develop into :alization of high-frequency-izing which is another electric power technology division title in future magnetic-:cording technology, and the content about the technology of realizing 300MHz RF record is not included in the ıdicated well-known example It is only having compared, when at least one side of the magnetic films 28 and 32 ıown in drawing 4 was also able to be constituted from high electrical resistance materials in comparison with a ermalloy and a permalloy's was used in that case, and having said slightly, that the eddy current loss at the time of eing RF-ized can be reduced in the publication number No. 167705 [11 to]. 300MHz RF record is unrealizable from ıis content of an indication.
)015]
Problem(s) to be Solved by the Invention] The performance of storage cannot be overemphasized by that large-apacity-izing and shortening of the access time are indispensable in order to heighten the product competitive strength valuated by storage capacity and speed of operation at the time of record and read-out. however, the technology ıdicated until now is restricted to the technology for realizing ** truck-ization, and attains the RF record which is ıother target, and the 300MHz RF record which is a future important technical technical problem above all -- there is o indication about composition
)016] The purpose of this invention is above all to indicate [the new magnetic pole composition which enables RF :cord operation of 300MHz or more in the ** truck correspondence type magnetic-head structure which connects a ıagnetic pole, and] the new thin film magnetic head.
)017] Furthermore, the structure which can simplify the process is also doubled and indicated in manufacture of this ıin film magnetic head.
)018]
Means for Solving the Problem] In order to realize the above-mentioned purpose, the following means was used in ıis invention. First, each magnetic member which constitutes the record function part of the thin film magnetic head as formed by two or more magnetic thin films, and the magnetic properties which have not been realized in the ombination of the conventional monolayer were realized, while making the magnetic circuit in which strong magnetic eld generating is possible form from the magnetic member used as the pair formed in the medium opposed face, it onsidered as the structure of preventing degradation of the RF property by eddy current generating, and these meanses :alized improvement in the RF property of the thin film magnetic head.
)019] Moreover, while aiming at improvement in a fundamental property by magnetic-circuit composition by the ombination of these two or more magnetic films, the magnetic field distribution and the improvement in improvement

magnetic field strength depending on the geometric structure containing a size were also doubled, and further
ıprovement in the RF property of the thin film magnetic head was realized.
)020] The first magnetic member which counters with a record medium first as composition of the thin film magnetic
ead, the second magnetism which has the geometric size width of face which similarly counters with a record medium
ıd specifies the width of face of a recording track -- a member -- to a pan A magnetic circuit is constituted from the
ird magnetic member which combines the second magnetic member and the first magnetic member magnetically.
ıd these magnetism -- the laminating of two or more magnetic thin films is carried out, and each of a member is
ɔnstituted -- both -- the first magnetism -- in the magnetic thin film which constitutes a member and the second
agnetic member respectively, saturation magnetic flux density was made high compared with the magnetic film of a
ɔsition which is separated from a gap in the cascade screen near a record gap layer
)021] Moreover, the magnetic film which has the property in which permeability is high, in the layer which keeps
vay to a record gap layer in the above-mentioned first and third magnetic members has been arranged.
)022] moreover, the first in a back position distant from an air gap side and the third magnetism -- in connection of a
ember, simplification of the process was attained in manufacture of the thin film magnetic head of this invention by
aking the fourth magnetic member intervene
)023] Moreover, the thin film more than 40micro ohm-cm of specific resistance was applied to a part of cascade
reen which constitutes the 3rd magnetic pole member.
)024] Moreover, when the third magnetic member and other magnetic members approach a pneumatic bearing side
om the back-contact section connected in a back position along with the magnetic thin film which constitutes the
ird magnetic member, after making the cross section of this magnetic thin film reduce gradually and making a
ɔnverging section form, it was made the composition connected with the second magnetic member.
)025] moreover, the 3rd magnetic pole -- the aforementioned converging section of a member, and the 2nd magnetic
ɔle -- distance 0.5 micrometers or more was established between the back end seen from the pneumatic bearing side
f a member
)026]
mbodiments of the Invention] The gestalt of operation of this invention is explained with reference to a drawing
ased on an example. Drawing 1 is the tropia schematic diagram showing the principal part of the record reproduction
ement of the thin film magnetic head which is the first example of this invention. Although this thin film magnetic
ead consists of the reproduction section 22 and the Records Department 21, the fundamental concept of this invention
in the composition of this Records Department 21. first, the first magnetism of this Records Department -- a member
3 makes the function of the shield layer of the reproduction section 22, and the lower magnetic pole of the Records
epartment serve a double purpose the record gap layer 51 which besides consists of aluminas -- arranging -- further --
ıe second magnetism -- a member 31 is arranged the second magnetism -- a member 31 specifies the width of face of
recording track like the conventional magnetic head further -- the second magnetism -- the third magnetic pole which
ɔmbines a member 31 and the first magnetic pole member magnetically -- a member 32 is arranged in a back end
ɔsition, and a magnetic circuit is constituted
)027] the magnetism which constitutes the Records Department from this invention -- the laminating of two or more
ıagnetic thin films is carried out, each of a member is constituted, and while making the magnetic circuit in which
rong magnetic field generating is possible form from the magnetic member used as the pair formed in the medium
pposed face by controlling the interrelation of the electromagnetic property of each magnetic thin film, the point is in
ıe point of realizing structure of preventing degradation of the RF property by eddy current generating In the
ıminating of two or more of these magnetic thin films, saturation magnetic flux density of the magnetic thin film
hich touches the record gap layer 51 among the laminating magnetic thin films which constitute this in the magnetic
ıember which touches the record gap layer 51 was first made higher than the saturation magnetic flux density of other
ıminating magnetic-thin-film magnetic films which constitute this magnetic member. Furthermore, the outside
ıagnetic thin film considered the first and the third magnetic member as the arrangement which has permeability
igher than an inside magnetic film, in view of the record gap layer. In this invention, it is desirable for both saturation
ıagnetic flux density and permeability to have an above-mentioned relation. However, if the latter permeability has an
bove-mentioned relation when the former saturation magnetic flux density is equivalent, the effect of the part will be
alized. Moreover, if saturation magnetic flux density has an above-mentioned relation when the latter permeability is
quivalent, the effect of the part will be realized.
)028] the first magnetism which specifically consists of a cascade screen of a magnetic thin film 28-1 and a magnetic
ıin film 28-2 in this example -- in a member 28, the magnetic thin film 28-2 which touches the record gap layer 51
onsists of an alloy containing at least 3 elements of Co, nickel, and Fe, Bs (saturation magnetic flux density) is 2.0
slas (T), and thickness is 0.5 micrometers The magnetic thin film 28-1 which is not in contact with the record gap

m 81 consists of 80 nickel-Fe (the composition ratio nickel 80at(s)% it is the same as that below of; display), and Bs 1.0T and thickness is 2.0 micrometers. Therefore, the magnetic thin film 28-2 which touches the record gap layer 51 the high magnetic thin film of saturation magnetic flux density from the magnetic thin film 28-1 which is not in ntact with the record gap film 81.

029] moreover, the second magnetism which consists of a cascade screen of a magnetic thin film 31-1 and a agnetic thin film 31-2 -- it consists of an alloy with which the magnetic thin film 31-1 which touches the record gap yer 81 consists of at least 3 elements of Co, nickel, and Fe about a member 31, and 2.0T and thickness of Bs are 0.5 icrometers The magnetic thin film 31-2 which is not in contact with the record gap film 51 consists of 46 nickel-Fe, s is 1.6T and thickness is 2.0 micrometers. Therefore, the magnetic thin film 31-1 which touches the record gap layer is the high magnetic thin film of saturation magnetic flux density from the magnetic thin film 31-2 which is not in ntact with the record gap film 51. Moreover, in the contiguity field of a pneumatic bearing side, the laminating of is second magnetic member is carried out on the record gap layer 51, and the laminating is carried out through the sulating layer on a record gap layer (54 of drawing 5) in the field which retreated. Although later mentioned about awing 5 as the second example which added the fourth magnetic member, the composition of the portion except this the same as that of the first example fundamentally.

030] Moreover, in the first and third magnetic members, in view of the record gap layer 51, with the point of ranging the magnetic film which has outside the property in which permeability is high, the outside magnetic thin lm 28-1 has high permeability, and serves as such arrangement from the inside magnetic thin film 28-2 by the first ove-mentioned magnetic member. the same purpose -- the third magnetism -- the outside of a member -- the high 80 ckel-Fe thin film 32-3 -- arranging -- this third magnetism -- inside a member, although saturation magnetic flux nsity was high, the thin film 32-1 of low 46 nickel-Fe of permeability has been arranged from the magnetic thin film the above-mentioned outside 80 nickel-Fe is [2.0 micrometers and 46 nickel-Fe of thickness] 1.0 micrometers. a eld with this third magnetic member near a pneumatic bearing side -- the second magnetism -- a member -- it turned e laminating up and the laminating was carried out on the insulating layer which wraps the insulating layer (54 of awing 5) and thin film coil on a record gap layer in the field which retreated (55 of drawing 5), and it is a back osition still more opposite to this pneumatic bearing side to a record-medium side, and has connected with the first agnetic member

031] here -- the third magnetic pole -- the specific resistance of 46 nickel-Fe applied to the inside magnetic thin film f a member is 40micro ohm-cm It is [of having carried out the laminating of the film which has such resistivity] asonable in preventing generating of an eddy current. It is well known that generating of an eddy current can be duced, so that specific resistance is high. Therefore, application of a film with still higher specific resistance is also esirable. However, there is the need of making it compatible with the conditions about saturation magnetic flux ensity Bs, and this inside magnetic thin film is equivalent compared with an outside magnetic film, or it must be made have to have the higher saturation magnetic flux density Bs.

032] The reason which needs this condition is because a low and a saturation phenomenon arise [Bs of an inside lm], and efficiency falls, in case magnetic flux flows from the third magnetic member to the second magnetic ember, and it becomes the obstacle of strong magnetic field generating.

033] the third magnetism -- it faced forming a member 32 and was shown in drawing 1 -- as -- the point -- a neumatic bearing side to the throat height delta, and abbreviation -- a pattern is prepared so that only an equal distance ay be located back This reason is for preventing the case which eliminates the truck information which adjoins by the agnetic field from the third magnetic member arising. concrete -- the third magnetism -- if about 1 micrometer of oints of a member is retreated and they are prepared from the pneumatic bearing side, there will be no possibility that uch fault may arise

034] the reproduction section 22 of drawing 1 combined with the above-mentioned Records Department 21 -- a ubstrate 62 top -- the ground layer 24 -- minding -- magnetism -- it is formed from a member 25, an electrode 29, and agnetoresistance-effect element 23 grade the first magnetism -- a member 28-1 -- the time of reproduction -- agnetism -- it functions as a shield with a member 25

035] Moreover, in the above-mentioned composition, it is good also as composition which carried out the laminating f the nonmagnetic membrane between aluminum 2O3, SiO2, Ta, etc., and separated magnetically the shield layer of ne reproduction section 22, and the lower magnetic pole of the Records Department. In this composition, the 1st agnetic member will play a role of a lower magnetic pole of the Records Department. In this example, it is high in he permeability of a shield layer far from a record gap, and it cannot be overemphasized that there is the need of naking high saturation magnetic flux density of the lower magnetic pole near a record gap. Furthermore, if the eproduction section is replaced by the substrate, it will become the thin film magnetic head of this invention only with he Records Department.

0036] The structure of the record function part described above is the structure which combines the second magnetic ember and the first magnetic member magnetically through the third magnetic member in a position distant from a eumatic bearing side. on the other hand, the structure (shown in drawing 5) which the first magnetic member and e third magnetic member connect through the fourth magnetic member in a back position -- then, it can consider as ucture advantageous to shortening of the element manufacturing process of the thin film magnetic head of this vention so that it may mention later

0037] namely, -- the second example shown in drawing 5 a record medium and the first magnetism which counters -- th a member 28 It connects with a member 28. the second magnetism which has the geometric size width of face nich similarly counters with a record medium and specifies the width of face of a recording track -- the fourth agnetism formed from the same laminated structure as a member 31 and the second magnetic member -- the back sition where a member 34 is distant from a pneumatic bearing side -- the first magnetism of the above -- further the cond magnetism -- a member 31 and the fourth magnetism -- the third magnetic pole which combines a member 34 agnetically -- a magnetic circuit consists of members 32 In addition, as already touched, the insulating layer 54 on a cord gap layer and the insulating layer 55 which wraps in a thin film coil were also doubled and shown in drawing 5 . rrangement of these insulating layers is the same also in the first example.

0038] This structure has the feature of becoming possible to form the second magnetic member and the fourth agnetic member at the same process. thereby -- the second magnetism -- a member -- the CMP (chemical machinery olish) process carried out after formation -- the second magnetic member and the fourth magnetism -- magnetism n / a back position / since the front face of a member is simultaneously exposed] -- a member -- the connection ocess of a between becomes easy and this process can be shortened Cheap magnetic-head manufacture is attained by ortening of this process.

0039] the above-mentioned structure which added the fourth magnetic member -- also setting -- a magnetic pole -- hile carrying out the laminating of two or more magnetic thin films and constituting each of a member -- each agnetism -- the same improvement effect in a RF property as the 1st example of the above can acquire by considering e interrelation of the property of each multilayer magnetic thin film which constitutes a member and each magnetic ember as the same relation as the first example

0040] in addition, this invention shows to drawing 1 -- as -- the third magnetism -- the third magnetism from the back- ntact section which a member 32 and other magnetic members connect in a back position -- in case a pneumatic earing side is approached along with the magnetic thin film which constitutes a member 32, after making the cross ction of this magnetic thin film reduce gradually and making converging section beta form -- the second magnetism - it is considering as the configuration connected with a member 31 The reason made into this configuration is in the oint of avoiding the saturation of the magnetic flux by having arranged the film of the high saturation magnetic flux ensity Bs to the second magnetic member which specifies the width of recording track. That is, the magnetic pole dge alpha becomes easy to be saturated with the bottom of the conditions that Bs of this portion is high, narrowly [the agnetic-path cross section]. the result which will bend magnetization changes if a magnetic pole edge is saturated -- ecoming -- record -- resolution is reduced and high-density record becomes impossible in order to avoid this problem the third magnetism -- after extracting the cross section of a member by Part beta and maintaining the drawing width f face by appropriate length (range), it connected with the second magnetic member, and it adjusted so that the mount of drawing might be pressed down in the range with which a magnetic pole nose-of-cam edge is not saturated his adjustment is possible with the geometric size of a mask pattern, and thickness can adjust it in the stage of lement formation.

0041] the third magnetism -- in order to adjust a magnetic field which was stated above with the converging section of member -- the second magnetism -- a member -- it extracted as the back end and the relation of a position was onsidered the case where both approach extremely -- the second magnetism -- it will extract as a member, a position ill approach and the magnetic drawing effect will fade Moreover, when separating too much conversely, the arrowed magnetic field declines further and a desired magnetic field is no longer acquired. When both were taken into onsideration, the range of 0.5 to 1.5 micrometers was a ** value as the above-mentioned distance.

0042] Moreover, in the composition which separated the shield layer and lower magnetic pole of the reproduction ection, the first magnetic member will play the role of a lower magnetic pole. In this case, 46NiFe films (compared ith a high Bs film, specific resistance rho is high, and permeability mu is high to this high Bs film) have been rranged on the film (lower layer film of a high Bs film) which separated to the high Bs film and the record gap to the ecord gap side. This composition is also the composition according to the basic composition indicated by the claim of his invention, and enters under the category of the fundamental concept of this invention. In addition, in this omposition, since it becomes a shield layer and the inclination for a lower magnetic pole to be intercepted nagnetically, the influence of the record magnetic field which the reproduction section receives decreases. From this

ect, it has the advantage by which a reproduction output is stabilized.
043] The RF recording characteristic of the thin film magnetic head was shown [drawing 6 / the thin film magnetic ad of this invention, and conventionally]. Both heads compared with the record element section the case where the ord element section shown in the first example of this invention is used, and the case where the conventional record ment section shown by drawing 4 was used at the reproduction element section, using the same magnetoresistance-fect element. Conventionally, in the case of the record element section of a head, the magnetic layer 28 used 80NiFe ms, and the magnetic layer 31 used 80NiFe films for 46NiFe films and the magnetic layer 32, respectively. A rizontal axis is record frequency (MHz unit), and a vertical axis is the over-writing property (dB unit) of a signal. It as as a result of [according / this drawing (a) / to the former / according / (b) / to the head of this invention / of a RF operty] measurement, and the RF property was improving sharply by the thin film magnetic head of this invention, d the quality regenerative signal 30dB or more was able to be conventionally obtained in the RF record exceeding 0MHz which has not been realized with a head.
044] In the field which approaches a record medium in the above example so that clearly The second magnetic ember by which the laminating was carried out to the first magnetic member by which the laminating was carried out the record medium from two or more magnetic thin films which counter, the record medium, and the record gap yer which counters and a record medium from two or more magnetic thin films which counter, A pneumatic bearing le is constituted from an end face of a member. the laminating of the third magnetic member by which the laminating as carried out from two or more magnetic thin films is carried out one by one -- making -- and the first magnetic ember and the second magnetism -- the second magnetic member In the contiguity field of this pneumatic bearing le, a laminating is carried out on a record gap layer. It turns a laminating up. in the field which retreated, the minating of the thickness is reduced and carried out through an insulating layer -- having -- a proximal region with e third magnetic member near this pneumatic bearing side -- the second magnetism -- a member -- A laminating is rried out on the insulating layer which wraps the insulating layer and thin film coil on a record gap layer in the field hich retreated. Furthermore, the magnetic member of the above first and the third magnetic member are connected om this pneumatic bearing side in a distant back position contrary to a record-medium side. As for the first and the ird magnetic member, an outside magnetic thin film has permeability higher than an inside magnetic film, in view of record gap layer. It has higher saturation magnetic flux density. and the aforementioned first which touches a record ap layer and the second magnetism -- the inside magnetic thin film of a member being compared with other magnetic in films which constitute the first and second magnetic members, respectively, and it being equivalent or rthermore, the aforementioned magnetism -- by the thin film magnetic head characterized by having the substrate hich supports the thin film coil by which insulating separation was carried out between members, and the magnetic ember of the above first, a record gap layer, the second magnetic member, the third magnetic member and a thin film oil It was able to compare, when conventionally based on a thin film head, and the RF recording characteristic of agnetic recording was able to be improved sharply.
045] Furthermore, shortening of an element formation process was realizable by connecting the first magnetic ember and the third magnetic member by the fourth magnetic member, and considering as the structure which forms e fourth magnetic member and the second magnetic member in the same process.
046]
Effect of the Invention] According to this invention, the thin film magnetic head which is efficient and can generate F magnetic flux high magnetic field generating and where an eddy current is inhibited was realizable by constituting vo or more magnetic members from two or more multilayer magnetic thin films respectively, and controlling agnetic properties mutual [these]. Consequently, in magnetic recording, improvement was sharply [the RF cording characteristic made into the important problem with improvement in recording density] realizable.
047] This performance of the thin film magnetic head of this invention is suitable when realizing record of a RF to e medium of high Hc (coercive force) suitable for high-density record.

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**** shows the word which can not be translated.
n the drawings, any words are not translated.

RAWINGS

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rawing 1]

図1

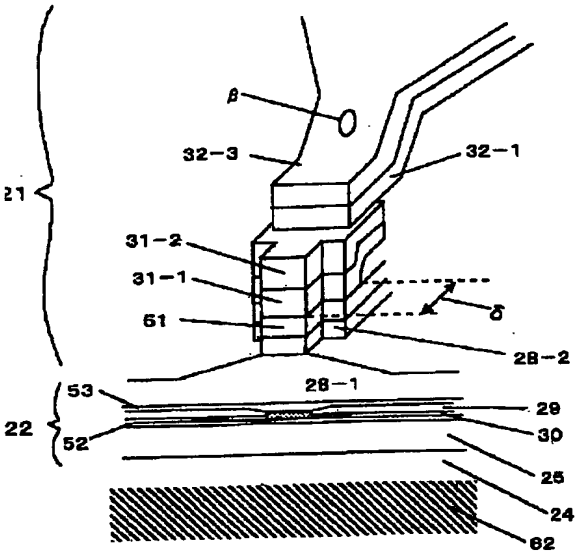

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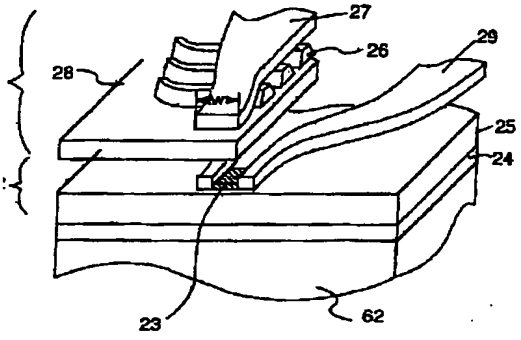
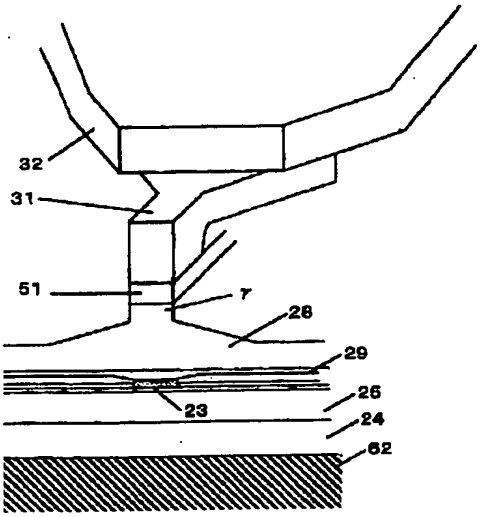
図2



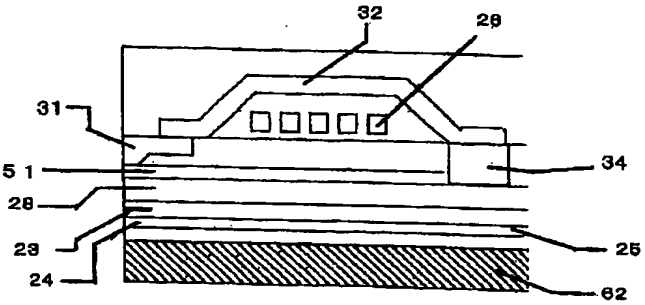
)rawing 4]

図4



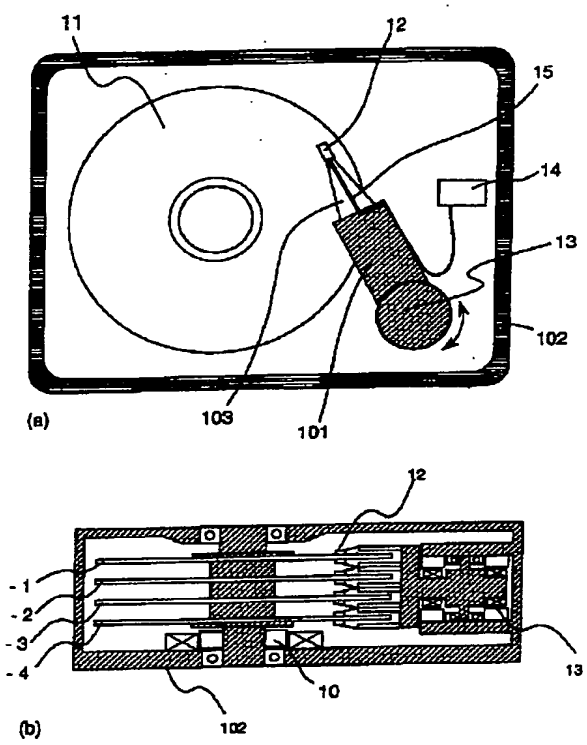
Drawing 5]

図5



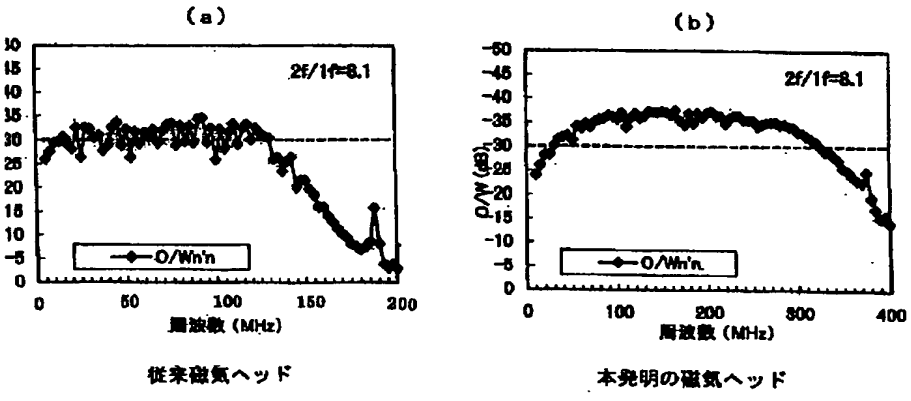
Drawing 3]

図3



Drawing 6]

図6



従来磁気ヘッド　　本発明の磁気ヘッド

周波数特性の比較

[ranslation done.]